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DESIGNING AN EFFICIENT EGG PRODUCTS PROCESSING PLANT

Marketing Research Report No. 1018

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
North Carolina State University

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PREFACE

This report deals with the layout of facilities, methods of operation, investment requirements, costs, and returns for a modern, efficient egg products processing plant designed for an initial production of 70 cases of eggs per hour with provisions for expansion.

The research was conducted under the supervision of John A. Hamann, chief of the Dairy and Poultry Products Marketing Laboratory, Northeastern Region, Agricultural Research Service, and in cooperation with the Department of Economics, North Carolina State University, Raleigh.

Appreciation is expressed to the egg products processing and handling equipment firms that furnished data on dimensions, installations, operations, and costs for the equipment, and to the management of commercial egg products plants that made their facilities available for study. Appreciation is expressed to G. R. Anderson, egg products national supervisor, and Richard Carey, food technologist, Poultry Division, Agricultural Marketing Service, U.S. Department of Agriculture, and to Charles B. Elks, assistant director, Division of Markets, North Carolina Department of Agriculture, for their review and assistance.

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Designing An Efficient Egg Products Processing Plant

By CLARENCE E. HARRIS, *marketing specialist, Dairy and Poultry Products Marketing Laboratory, Northeastern Region, Agricultural Research Service,* and R. CHARLES BROOKS, *extension professor, Department of Economics, North Carolina State University*

SUMMARY

The purpose of this study was to develop an efficient layout for an egg products processing plant and to determine investment estimates, operating costs, labor requirements, and potential returns to guide those planning the construction and operation of such a plant.

Some factors to consider in selecting a site are discussed.

A recommended layout for an egg products processing plant is described and illustrated. It was designed for efficient operation at an hourly production rate of 70 standard cases containing 30 dozen eggs each and met the requirements of the Egg Products Inspection Act. Features of the layout provide adaptability to handle the end product as fresh chilled liquid or as a frozen product. Each area of the plant is discussed in order of the product flow, and the recommended methods of operation along with the area descriptions are included.

Also discussed are the initial investment and fixed and variable costs. An analysis was made to determine costs and potential returns at various output levels. This analysis indicates the sensitivity of the size of processing and marketing margins on potential net returns. Each prospective investor should use the expected cost and return data appropriate to his individual situation.

BACKGROUND

The production and consumption of egg products[1] have increased faster than shell egg production and consumption since the 1950's (*4*).[2] In 1951, 6.9 percent of total egg production was marketed as egg products compared with 11.5 percent in 1971 (table 7, appendix), an annual increase from about 10.6 to more than 23.4 million cases of 30 dozen eggs each.[3]

In the past, most egg products plants were seasonal operations because shell egg production fluctuated. These plants were an important outlet for the surplus eggs produced in late winter and spring. In recent years, egg production has become less seasonal, and the function of many egg products plants has changed. The Egg Products Inspection Act (*6*), which became effective on July 1, 1972, restricted the use of undergrade eggs to the egg products market (*7*). Consequently, most egg products plants now provide a market for this type of egg, and some operate throughout the year with seasonal fluctuation in the number of hours of operation per week.

As egg products plants have become less seasonal in operation, the need for efficiency has increased. Prior to 1950–51, all egg-breaking and separating operations were done by hand labor (*4*). An efficient worker could break and separate from 2½ to 3 cases per hour. With the development of breaking machines in the 1950's, an efficient operator could monitor a machine that broke and separated approximately 16 cases per hour. Since then, machines have been developed that break and separate in excess of 30 cases of eggs per hour. Although the production rates of breaking machines have increased, more efficient methods for handling the product, packaging materials, and waste are needed. The layout of the processing plant, including the location and interrelationship of the equipment, workrooms, storage areas, employee welfare areas, and office space, contributes markedly to operating efficiency.

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[1] Include whole eggs, whole egg blends, albumen or whites, and plain, sugared, and salted yolks in liquid, frozen, or dried form.

[2] Italic numbers in parentheses refer to Literature Cited, p. 21.

[3] Unpublished data from Statistical Reporting Service and Agricultural Marketing Service, U.S. Department of Agriculture.

The purpose of this study was to develop an efficient layout for an egg products processing plant and to determine investment estimates operating costs, labor requirements, and potential returns to guide those planning the construction and operation of such a plant.

SELECTING A SITE

The egg products plant should be located at the center of a 240- by 260-foot site (fig. 1). This size of site will provide sufficient space for (1) expanding the plant to twice its original size, (2) driveways to the front and sides of the plant, and (3) parking spaces for trucks and automobiles. The site plan is based on the use of a land area where the truck parking area is lower either naturally or by grading than the opposite side of the site.

Selecting a suitable geographical location for an egg products plant includes such considerations as (1) an adequate supply of egg-breaking stock at a competitive price, (2) markets within a convenient hauling distance, (3) an adequate and dependable labor force, (4) the availability of public cold-storage facilities in the area, (5) the availability of all-weather roads, and (6) a satisfactory water supply, other utilities, and waste-disposal facilities.

If all the breaking stock is expected to come from one shell egg grading and packing plant, the egg products plant should be located near or adjacent to it. An egg products plant should be in an area reasonably free of objectionable odors, smoke, flying ash, and dust, which are sometimes produced by oil refineries, city dumps, chemical plants, sewage-disposal plants, dyeworks, and paper pulpmills (*8*). Locating an egg products plant in a heavily populated area may generate complaints about occasional offensive odors and insects. The site selected should permit facility compliance with government regulations.

Other considerations in selecting a site for the plant include the size of plots available; grading, drainage, and soil conditions; initial cost of the land; cost of connecting to public roads and utilities; and prevailing tax and insurance rates (*3*).

The total amount spent for a plant site usually is relatively small compared with the cost of the building (*1*). For this reason the price of the land should not be considered as a barrier until all other factors have been studied and their value to the plant has been determined. Generally the site size should not be less than five times the size of the building to allow for rail sidings, loading platforms, truck ingress and egress, and future expansion (*5*). The site plan (fig. 1) provides more than five times the number of square feet required for the building.

DESCRIPTION OF FACILITIES AND OPERATIONS

Plans developed in this report incorporate the principles of good layout for an efficient egg products processing plant. These plans are not intended for any specific location or operation, but they are general recommendations, which are applicable as a guide in designing individual facilities. The facilities may be constructed as a self-contained operation or may be added to an existing shell egg grading and packing plant.

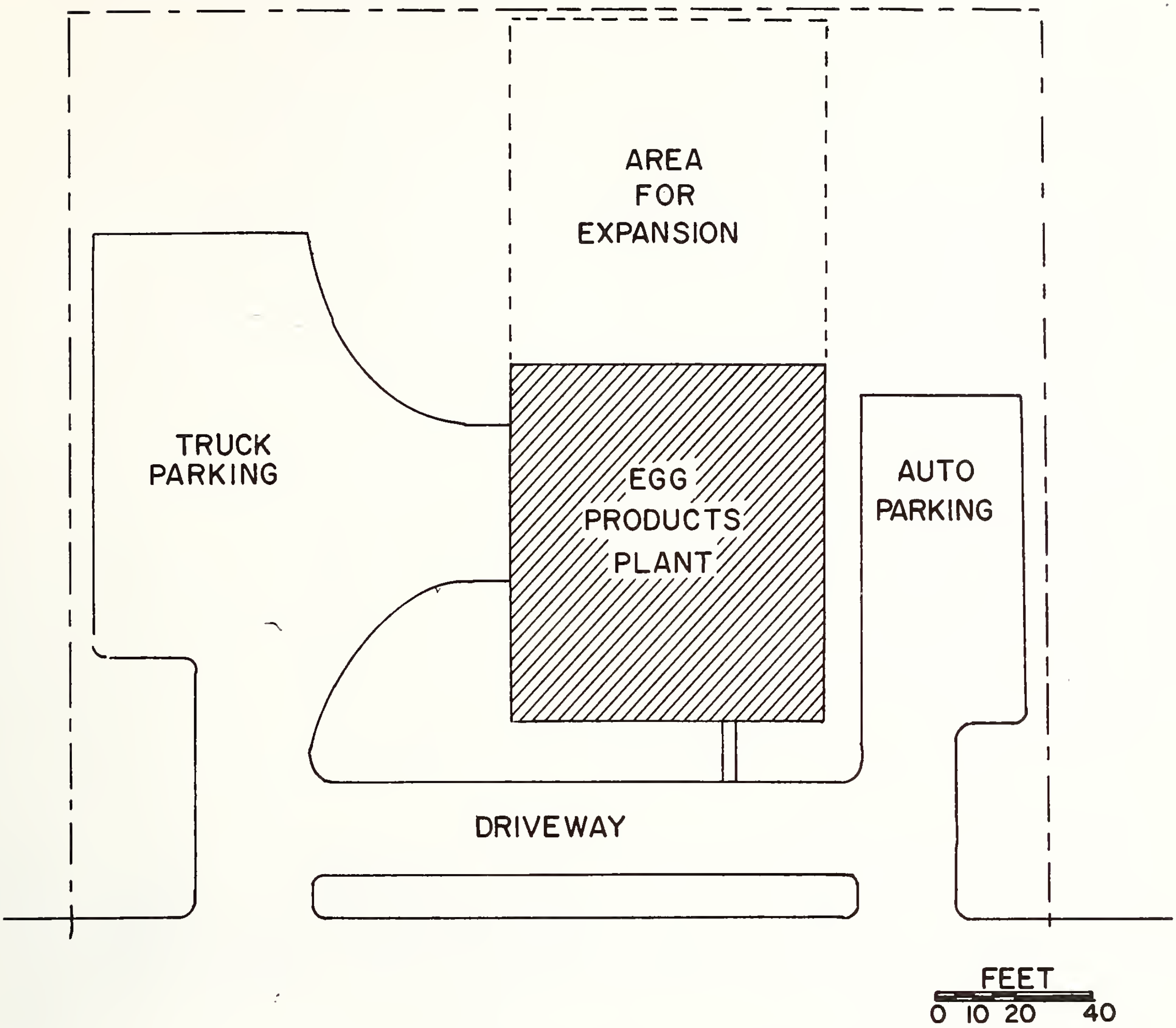

FIGURE 1.—Site plan for an egg products plant.

The facility is designed for breaking and processing an average of 70 cases of eggs per hour, assuming that good-quality breaking stock will be used. This production rate was selected because the facility was planned around two modern high-speed egg-breaking machines, which are rated at 30 to 50 cases per hour by the manufacturers. In establishing the estimated production rate, such factors were considered as spaces left on conveyors between packers' lots, removal of dirty eggs, and eggs lost during washing.

The major processing operation in any egg products plant is removal of the egg meats from the shells. Auxiliary operations prior to breaking the shell eggs include receiving and weighing, cooling and storing, washing, and grading. Auxiliary operations after breaking are disposing of shells, inspecting egg meat, separating yolks and whites, clarifying and churning, adding ingredients, cooling and storing, pasteurizing, packaging, freezing, storing, and shipping. These operations vary from one egg products plant to another and with some flexibility in each overall operation.

The flow chart in figure 2 shows the operations described in this study. Some of them may be bypassed and are indicated as optional in this diagram. An example is when eggs are broken very soon after they are received. They might go directly to the transferring, washing, grading, and breaking operations and bypass being cooled and stored. Another example would be egg meat shipped as fresh liquid. It would bypass the freezing and storing operations. The product mix will dictate the operations performed.

It is assumed that most of the breaking stock for this egg products plant originates from nearby shell egg grading and packing plants. If the plants are operated by the same management, the shell eggs are generally packed in heavy duty, reusable fiberboard cases with pulp filler flats. If plastic filler flats are used, these flats are stacked on pallets without the fiberboard cases. Breaking stock from other sources would probably come to the egg products plant in lightweight fiberboard cases with pulp filler flats, which can be destroyed or reused if, after the eggs are removed, they are in reasonably good condition.

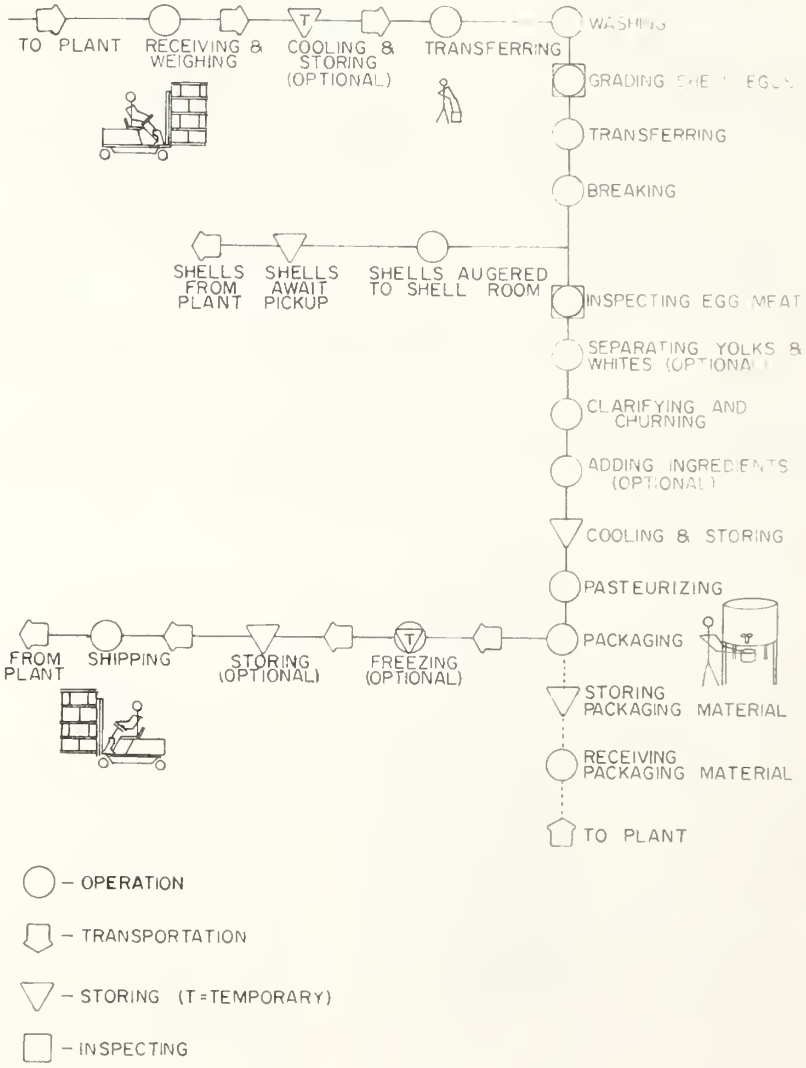

FIGURE 2.—Flow chart for egg products processing operations.

BUILDING DESIGN AND CONSTRUCTION

The egg products plant (figs. 3 and 4) contains approximately 8,000 square feet of enclosed floorspace. The rectangular building has a flat roof with a ceiling height of 14 feet throughout the building, except offices, employee welfare areas, laboratory, ingredients storage and cleaning supplies rooms, and hallways. These areas have an 8-foot-high ceiling.

The concrete floor throughout the plant is at one level to permit the rapid and efficient movement of personnel, products, packaging materials, and materials-handling equipment. It has a troweled finish and is adequately reenforced in heavy load-bearing areas.

The land on which the plant is located is graded to provide a truck parking area. Where excavation is necessary, drainage should be provided. This parking area is 48 inches lower than the outer edge of the receiving and shipping area floor. When trucks are positioned at the 8-foot-wide receiving and shipping doors, the floor of the average truck bed should be approximately the same height as the floor of the receiving and shipping area to facilitate rapid and efficient unitized movement of products and materials.

Floors, walls, ceilings, doors, and other facilities throughout the plant are to be constructed and installed according to regulations (*7*). Anyone planning to operate an egg products plant should receive approval of his building plans from the regulatory agencies before construction is started.

Space within the plant includes an enclosed receiving and shipping area, cooler, transfer and empty-case room, breaking room, drawoff room, freezers, shop and boilerroom, and auxiliary areas. The plant layout (fig. 4) shows the arrangement and interrelationship of these rooms and areas to each other and the major items of equipment.

Receiving and Shipping Area

The receiving and shipping area is 14 feet wide by 42 feet 4 inches long and contains approximately 580 square feet of floorspace.

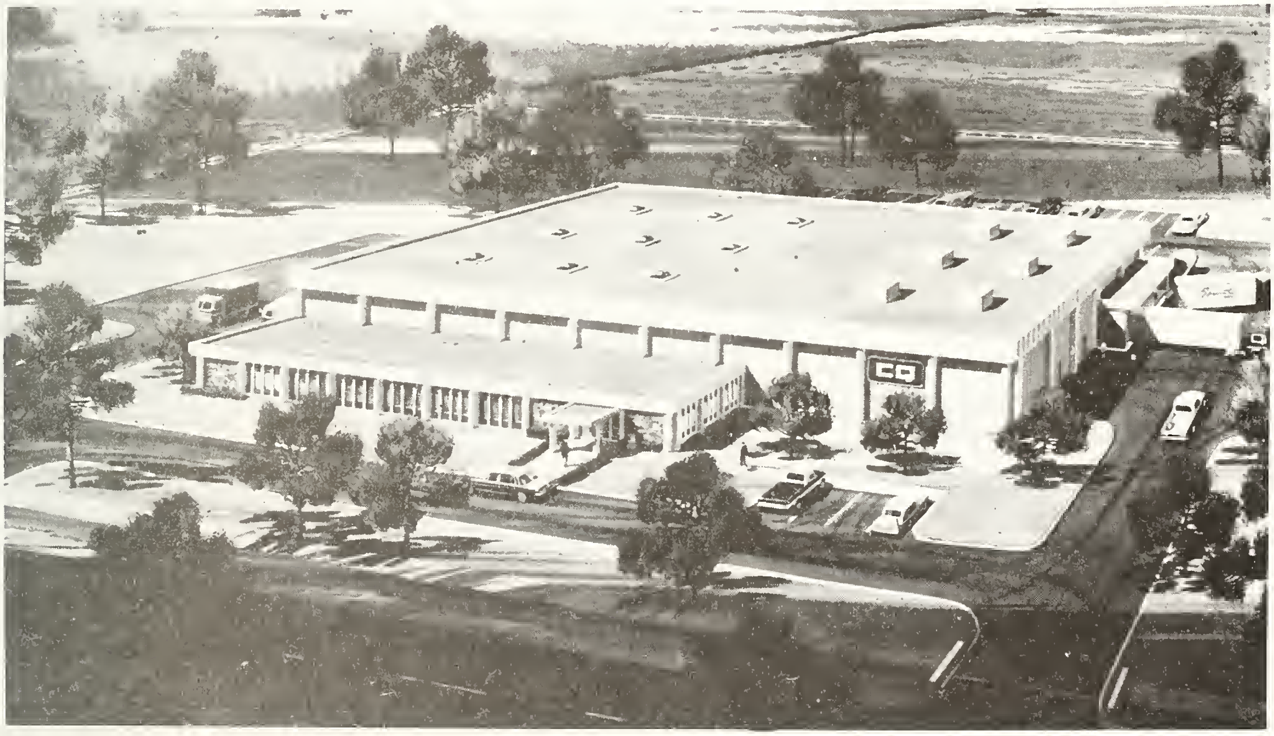
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FIGURE 3.—Model of an egg products processing plant.

The area is enclosed to protect personnel and products from the weather and serves as a vestibule for the cooler and the freezer. Three overhead doors, 8 feet wide and equipped with truck seals, facilitate loading and unloading of trucks while minimizing refrigeration loss (fig. 5). A 3-foot door provides access for personnel. Other doors lead to the shop and boilerroom, cooler, freezer, and packaging-material storage area. The doorway to the freezer is equipped with a self-closing, shock-absorbing type of door, in addition to an insulated sliding door. The floor of the receiving and shipping area slopes slightly toward the outside doorway.

Within the receiving and shipping area is an office, 4 by 5 feet, for the person in charge of receiving and shipping. It has windows on two sides for observing activities in the area.

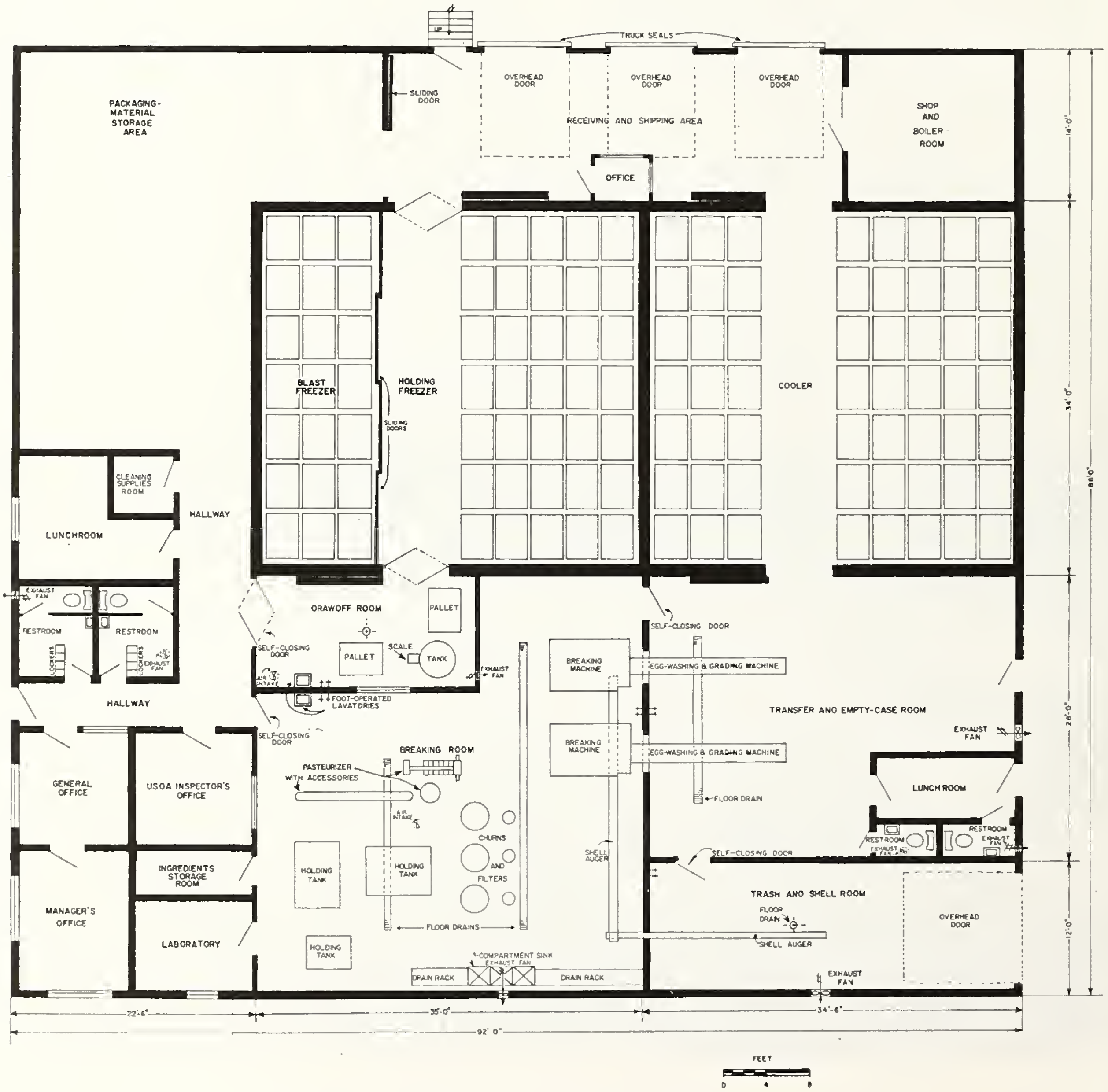

FIGURE 4.—Layout of an egg products processing plant.

Cooler

The cooler, 32 by 33 feet, contains approximately 1,060 square feet of floorspace. When loaded to capacity it will accommodate 112 pallet loads of eggs when the pallets are double stacked and measure 36 by 48 inches. These dimensions provide space for 30 cases of eggs per pallet when using one of the popular stacking patterns for 30 dozen egg cases (*3*). Thus the cooler has the capacity for 1,680 cases when stacked one pallet high and 3,360 cases when stacked two pallets high. The cooler area is designed to allow 6 inches of space around each pallet for air circulation. Refrigeration coils and blower equipment should be suspended from the 14-foot ceiling so that they do not occupy floorspace and should provide good air circulation over and around the eggs.

Under normal operating conditions the cooler should be maintained at approximately 50° F, and eggs are generally stored there for 24 hours or longer before they are broken.

Transfer and Empty-Case Room

The transfer and empty-case room adjoining the breaking room provides approximately 725 square feet of space for accumulating empty cases and sufficient space for two egg-washing and grading machines, a stack of empty pallets, and space for maneuvering pallets of eggs.

The concrete floor in this room slopes to a trench drain serving both washing and grading machines. Water from these machines is piped into the drain to minimize any water on the floor. Hot- and cold-water outlets are provided for cleaning purposes. Each washing and grad-

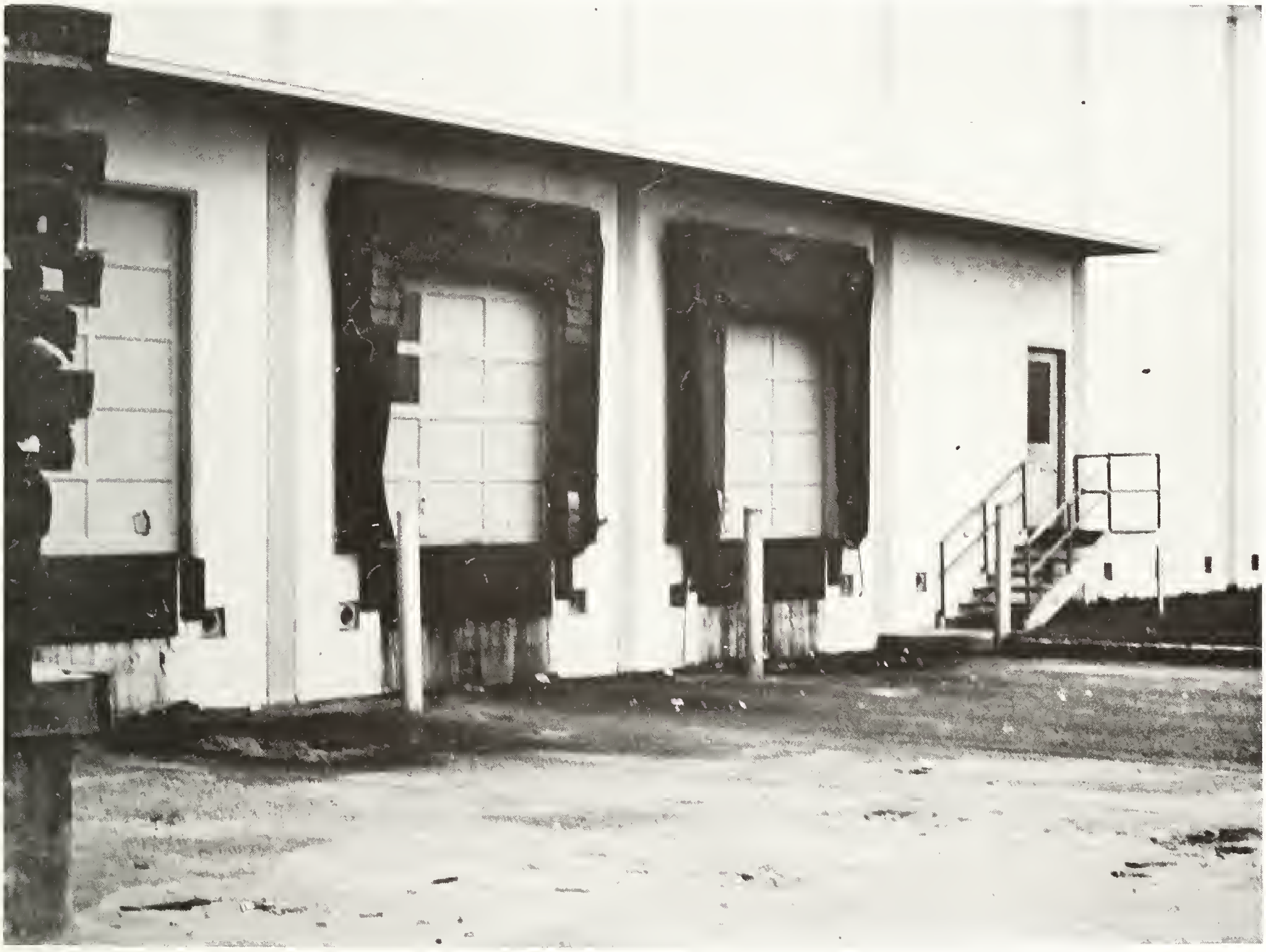

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FIGURE 5.—Doors with truck seals and bumpers at receiving and shipping area of egg products processing plant.

ing machine has water and electrical outlets and a hood with an air duct to the outside of the building. The air ducts are equipped with fans to remove hot air and steam from the egg-washing and grading operations. Doors to the breaking room and the trash and shell room are equipped with self-closing devices.

Eggs are brought into the transfer and empty-case room on pallets, positioned adjacent to the washing and grading machines, and transferred from the filler flats to the machines' conveyors. After the eggs are washed, graded, and dried, they are transferred to the breaking machines.

Breaking Room

The area of the breaking and drawoff rooms is 35 by 37 feet and contains 1,295 square feet of floorspace. The breaking room is designed around two breaking machines, with sufficient floorspace to process and store the volume of the product broken by these machines. In addition to these two machines, other major items of equipment in this room include filters, three churns, a plate pasteurizer with accessories, three refrigerated holding tanks, a three-compartment sink with drain racks, a shell auger, and a foot-operated hand-washing lavatory.[4] The equipment is arranged in the room to provide for a smooth, orderly flow of the product and to allow sufficient space around each piece of equipment for cleaning and servicing.

A positive flow of clean air is provided for the breaking room by air-conditioning units located on the roof over the breaking and drawoff rooms. These units heat or cool and filter the main air supply. Air flows out of the breaking and drawoff rooms into the transfer and empty-case room, where an exhaust fan is located.

The floor of the room slopes to two trench drains for rapid removal of water from the floor. One floor drain is near the breaking machines and the other is near the pasteurizer and holding tanks in order to expedite water runoff during cleanup. This room has two sets of hot- and cold-water outlets for cleaning purposes. Also, hot- and cold-water outlets are provided at the three-compartment sink and at the breaking machines.

Shell eggs are transported from the transfer room to the breaking room by the washing and grading machine roller conveyors that extend through 12- by 24-inch openings in the wall separating the two rooms. In the breaking room the eggs are transferred mechanically to the breaking machines, where the shells are opened and their contents emptied sequentially into cups mounted on a conveyor. It moves the broken-out meats past the trained machine operator, who continuously inspects the product and controls the machine (fig. 6). After the eggs are broken, the empty shells are dropped into a shell auger, which transports them to the trash and shell room for disposal. The egg meat, either as separated yolks and whites or as whole egg, is pumped through churns and filters and then into a refrigerated holding tank.

When a sufficient quantity of the product has been collected in the holding tank, ingredients may be added[5] as required, and then the mixture is blended, pasteurized, and pumped to a tank in the drawoff room. A pasteurizer and a holding tank are shown in figure 7. Ingredients to be added to the product are taken into the breaking room from their storage room as needed. Utensils and most small items of equipment in the breaking room are washed, rinsed, and sanitized in the three-compartment sink and allowed to drain on the adjacent racks (fig. 4).

Drawoff Room

The 10- by 20-foot drawoff room (fig. 4) provides space for a 200-gallon drawoff tank, scale, pallet of packaging materials, 36- by 48-inch pallet for stacking the packaged product, as well as cleanup facilities.

A refrigerated or heated air-conditioning unit in the ceiling moves filtered air into the room. A 5-foot observation window is in the wall between the drawoff and breaking rooms.

When sufficient product has been pumped from the pasteurizer in the breaking room into

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[4] Equipment illustrated in figure 4 is not designed to depict any particular type but to occupy an appropriate amount of floorspace.

[5] When abrasive or corrosive ingredients are used, pasteurization generally precedes their addition to the product.

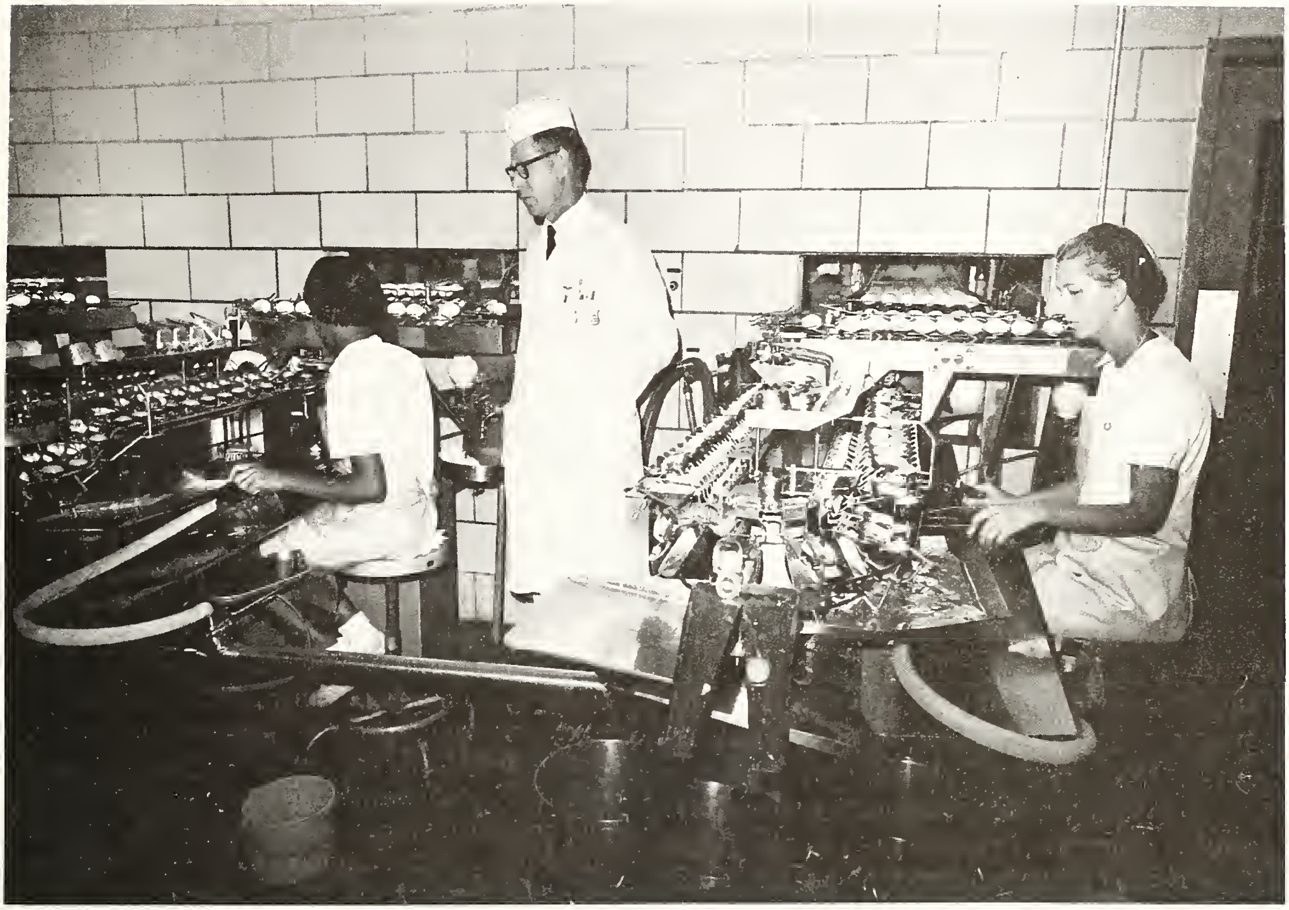

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FIGURE 6.—Mechanized egg-breaking operation under continuous supervision of USDA inspector.

the tank in the drawoff room, it is poured into cans or other containers, weighed, sealed, and stacked on a pallet. The pallets of packaged product are moved to the blast freezer promptly.

The drawoff room is designed to facilitate packing in cans, plastic bags, bottles or jugs, and portable refrigerated tanks of up to 200-gallon capacity (fig. 8).

Blast Freezer

The 10- by 32-foot blast freezer with an inside height of 14 feet contains approximately 320 square feet of floorspace. Pallets of the product are moved into and out of the blast freezer through four sliding doors, 8 feet 6 inches wide, on one side of the freezer. Each door allows two rows of pallets to be moved into or out of the blast freezer, and each pair of doors can be moved aside to allow the adjacent two rows of pallets to be moved in or out.

The blast freezer can hold 21 pallets of product without high stacking and 42 pallets when stacking two high. When the product is packaged in 30-pound cans and stacked on 21 pallets, 36 by 48 inches, with 48 cans per pallet, the blast freezer can accommodate 30,240 pounds of product without double stacking and 60,480 pounds with double stacking. The cans should be separated by boards and bound to stabilize the load. Approximately a 2-inch space is available on all sides of each can for air circulation, and approximately 4 feet of space will be left between the ceiling and the product when the pallets are high stacked. The refrigeration coils are suspended from the ceiling to provide optimum air circulation and to leave the floor area for storing the product.

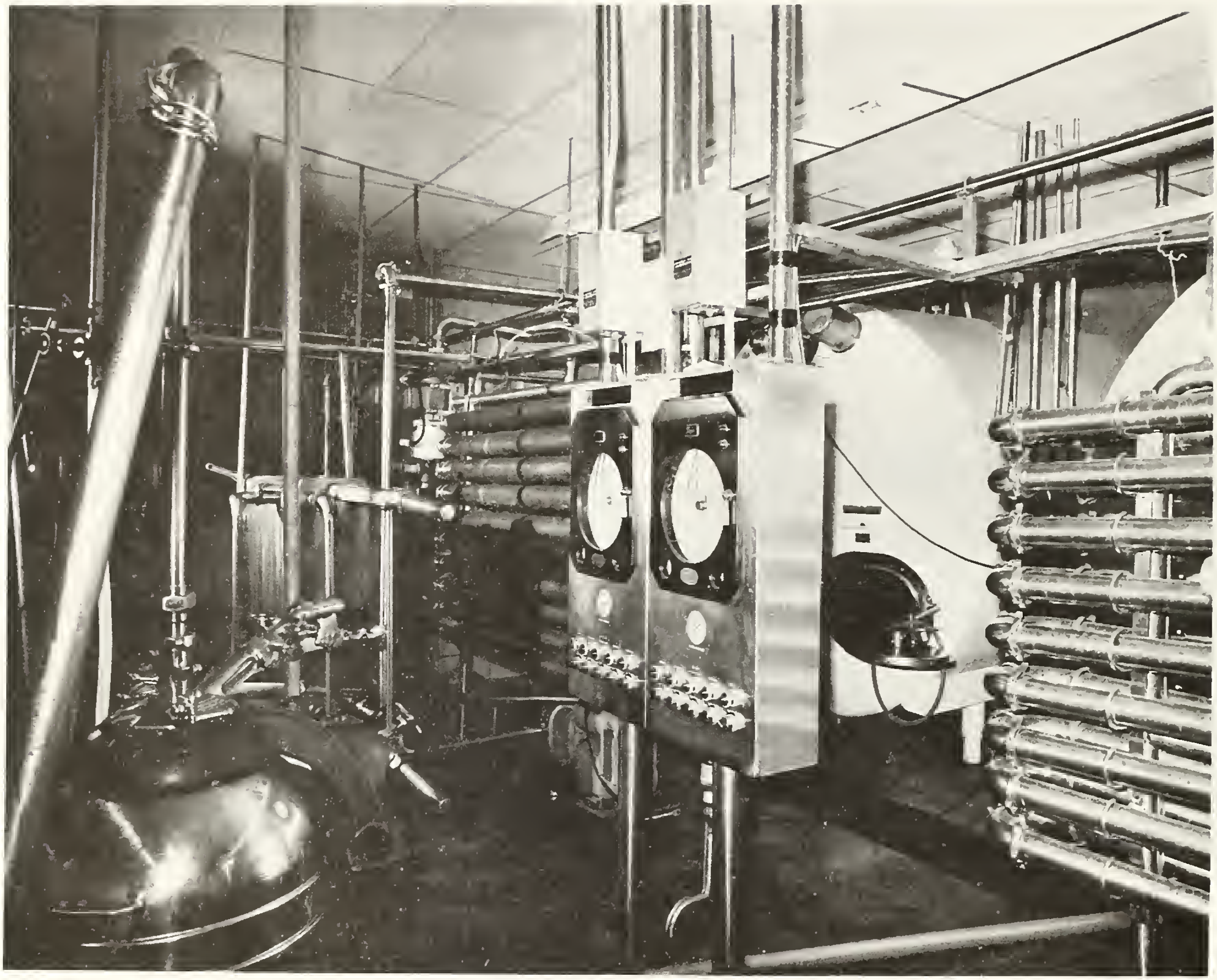

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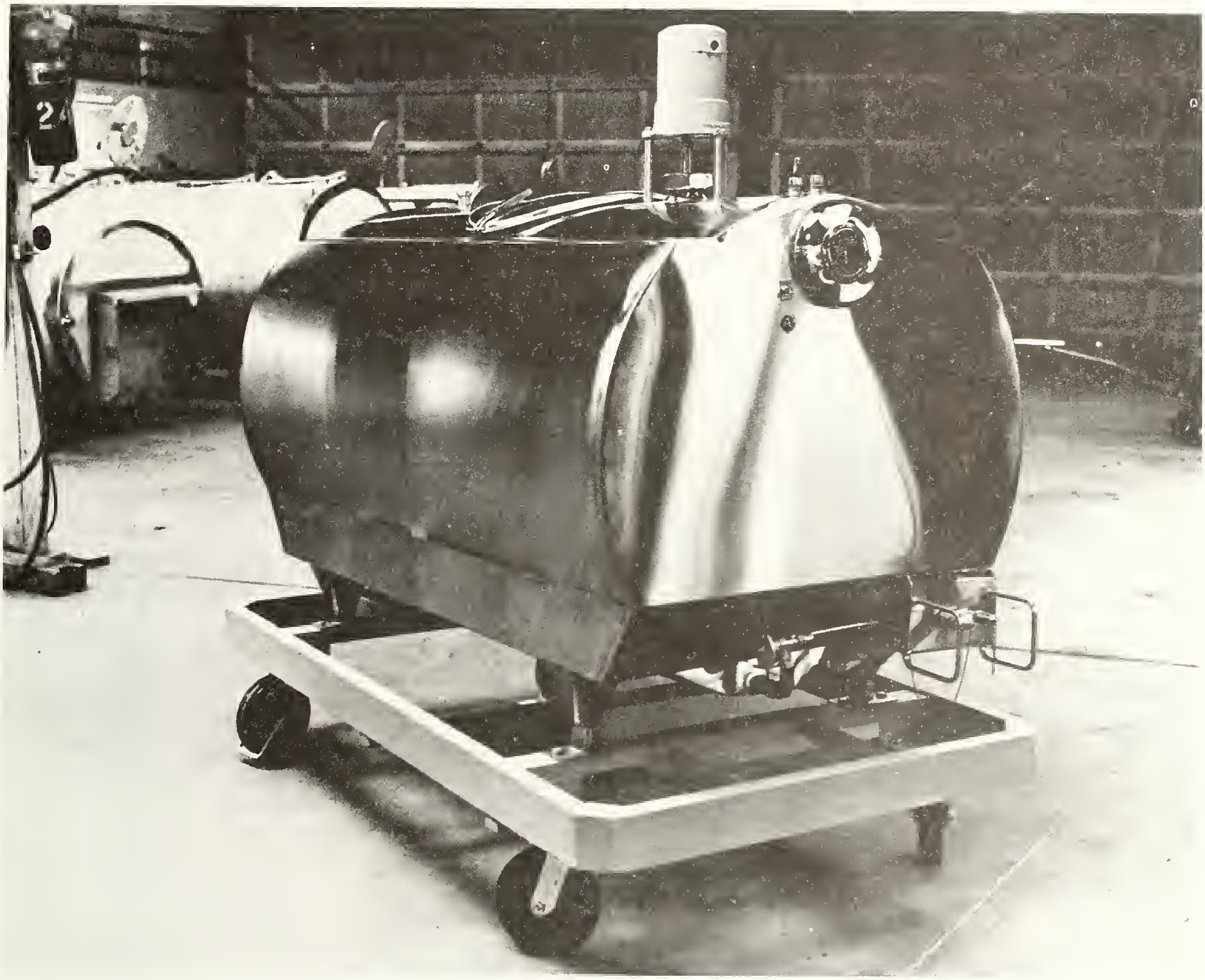
FIGURE 7.—High-temperature short-time pasteurizer in foreground and holding tank in background for egg products.

The palletized product is held in the blast freezer until it has been adequately chilled or frozen. Pasteurized egg products to be frozen should be solidly frozen or their temperature reduced to 10° F or lower within 60 hours of pasteurization (*7*). The blast freezer is designed to accommodate 3 days of production from the breaking room.

Holding Freezer

The 23- by 32-foot holding freezer contains approximately 740 square feet of floorspace. It has a 14-foot-high ceiling and an 8-foot aisle, which provides access to the blast freezer. Each doorway is equipped with two 3-foot self-closing bumper doors plus an insulated sliding door. The holding freezer has sufficient space for 35 pallets of product without high stacking or 70 when stacking two high. By stacking 30-pound cans of product with 48 cans per pallet, this freezer can hold 100,800 pounds of product or approximately 5 days of plant production.

In the layout (fig. 4) the blast freezer is located within the holding freezer and the holding freezer is adjacent to the cooler, which is next to the shop and boilerroom, where the refrigeration equipment is housed. Advantages of this arrangement include (1) less refrigeration loss when doors of the blast freezer are opened to the holding freezer than when doors



PN-3603

Figure 8.—Portable refrigerated tank for storing fresh liquid eggs. It can be moved into a customer's facility and operated on a 110-volt outlet.

are opened into nonrefrigerated space; (2) less refrigeration loss through common walls; (3) lower construction costs because less insulation is needed in common walls and less piping is needed for refrigerant; (4) nearness of all refrigerated rooms to the refrigeration equipment, minimizing the distance the refrigerant must be piped; and (5) centralization of all receiving and shipping operations so that labor and equipment are cross-utilized and supervisory requirements are reduced to a minimum.

Shop and Boilerroom

The 13- by 15-foot shop and boilerroom has approximately 200 square feet of floorspace for housing two refrigeration compressors, an air compressor, workbench, electrical power-supply panel, and hot-water boiler. The refrigerant storage tank can be suspended from the 14-foot ceiling. The evaporative condenser for the refrigeration system is installed on the roof. A doorway, 6 feet wide and 8 feet high, to the receiving and shipping area provides access for moving large equipment in and out of the room.

Auxiliary Areas

Plant areas other than those where the product is processed, frozen, or stored are referred to as auxiliary areas. They include (1) a packaging-material storage area, (2) employee welfare areas, (3) offices, (4) hallways, (5) trash and shell room, (6) laboratory, and (7) ingredients storage and cleaning supplies rooms.

Packaging-Material Storage Area

This area contains a 21- by 35-foot and a 12- by 13-foot contiguous section with approximately 900 square feet of floorspace. One hundred pallets of packaging materials stacked two pallets high can be stored in it. Each pallet can hold 48 wrapped and sealed 30-pound egg meat cans when stacked 4 bundles high per pallet with each bundle containing 12 cans (*3*). If a nesting type of packaging material is used, such as plastic cartons, the effective storage capacity would be substantially increased. The packaging-material storage area is convenient to the drawoff room and the receiving and shipping area.

Employee Welfare Areas

Two areas in the plant are for the welfare of the workers. Each includes two restrooms and a lunchroom. One area, 9 by 12 feet, adjoins the transfer and empty-case room. The workers in this room do not have to use the breaking room as a passageway because they have a separate entrance to their work area through the lunchroom. The other welfare area for the other employees and the visitors is adjacent to the offices and has approximately 250 square feet of floorspace.

The USDA inspection service suggests a separate welfare area for workers exposed to shell egg packing-material dust, which may accidentally contaminate the pasteurized product.

Offices

Three offices are at the front of the plant. The 10- by 10-foot USDA inspector's office is large enough for a desk, chair, and lockers or cabinets for records and supplies. The location next to the breaking room is convenient for the inspector in performing his duties. There are two management offices, one 10 by 10 and the other 10 by 12 feet. One is for general office work and reception of visitors and the other for the manager.

Hallways

One hallway, 4 by 14 feet, extends between the offices and restrooms. The other, 7 by 25 feet, provides additional width for moving products and materials to various areas in the plant. It can also be used by those going to the welfare area or obtaining cleaning supplies.

Trash and Shell Room

The 11- by 33-foot trash and shell room contains approximately 375 square feet of floorspace. The floor slopes one-fourth inch per foot to the floor drain in the center of the room. This room is equipped with hot- and cold-water outlets for cleaning purposes and an exhaust fan. Shells are collected in a container or truck as the shell auger discharges them, and they are periodically removed from the plant. A 10- by 10-foot screened doorway permits truck entry and a 3-foot doorway provides pedestrian access to the room from the transfer and empty-case room.

Laboratory

An 8- by 10-foot laboratory opens into the breaking room to permit regular, rapid, quality-control sampling of products and checking of equipment cleanliness.

Ingredients Storage and Cleaning Supplies Rooms

The 4- by 10-foot ingredients storage room and the 5- by 5-foot cleaning supplies room are not much more than large closets with shelves for small containers and approximately 70 square feet of floorspace for large drums. Adequate storage space is provided for mix ingredients and cleaning supplies near areas where they are needed.

INITIAL INVESTMENT

The financial requirements for an egg products processing facility include investment costs for land, building, and equipment, as well as operating capital. The investment requirements developed in this study were land and site improvements $32,000, building $165,000, and equipment $159,133. In addition, it is assumed that $65,000 will be needed for operating capital. The overall financial requirements totaled $421,133 under the conditions and assumptions included in the study (table 1).

Building

A large part of the total investment cost for an egg products facility, like most other processing plants, is the building. A desirable plant layout with a short, direct flow of product, packaging material, and waste can help minimize building costs by reducing the size of building needed. A well-planned layout helps to minimize labor use and to achieve other efficiencies in addition to reducing initial building costs. The layout in figure 4 was developed to minimize building cost and to achieve processing efficiency.

The cost estimate of constructing a building according to the layout (fig. 4) was determined with the assistance of equipment company representatives, industrial construction contractors, and professional people familiar with the various kinds of construction and materials required for the type of facility described in this report. The total building cost was estimated at approximately $21 per square foot. This estimate included the cost of electrical wiring, plumbing, insulation, air-conditioning, refrigeration, and heating equipment.

TABLE 1.—*Estimated initial investment and annual fixed overhead costs for an egg products plant with 2 breaking machines* [1]

Item	Units	Initial investment	Expected life	Annual fixed overhead costs				
				Interest [2]	Depreciation	Repair and maintenance [3]	Taxes and insurance [4]	Total
	Number		*Years*					
Land	1	$ 32,000	--	$ 2,240	-----	----	$ 736	$ 2,976
Building [5]	1	165,000	25	5,775	$ 6,600	$4,125	3,795	20,295
Equipment:								
Egg-washing and grading machines	2	12,000	10	420	1,200	480	276	2,376
Breaking machines	2	60,000	10	2,100	6,000	2,400	1,380	11,880
Pasteurizer with accessories	1	25,790	12	903	2,141	1,032	593	4,669
Holding tanks	4	15,890	20	556	795	159	365	1,875
Cleaning system	1	4,300	12	151	357	129	99	736
Spare fittings, valves, tubing	1	8,000	12	280	664	240	184	1,368
Egg churns	6	5,880	12	206	488	176	135	1,005
Egg filters	3	1,185	12	41	98	36	27	202
Pumps	6	1,782	12	62	148	53	41	304
Air compressor	1	1,300	12	46	108	39	30	223
Shell augers	2	1,200	12	42	100	36	28	206
Refractometer	1	1,100	12	39	91	33	25	188
Pallets	220	1,100	12	39	91	33	25	188
Electric fork truck	1	7,500	12	263	623	225	173	1,284
Miscellaneous	---	4,606	12	161	382	138	106	787
Installation of equipment	---	7,500	--	263	-----	----	----	263
Operating capital	---	65,000	--	4,550	-----	----	----	4,550
Total	---	421,133	--	18,137	19,886	9,334	8,018	55,375

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[1] Cost data based on June 1973 quotations.

[2] 7 percent of average investment computed at 50 percent except for land and operating capital.

[3] 2.5 percent for building, 4 percent for washing and breaking equipment, 1 percent for tanks, and 3 percent for all other equipment.

[4] 2.3 percent except installation of equipment and operating capital.

[5] Heating, air-conditioning, and refrigeration included in building costs.

Equipment

The equipment required for the operation projected in this study is based on the layout (fig. 4) and was selected on its rated capacity of 5,530,000 pounds of processed product per year. Equipment requirements and estimated costs are given in table 1.

Operating Capital

In all businesses there is a time lag between the purchase of raw materials, processing the raw materials into finished products, sale and delivery of final products, and receiving pay from these sales. Because of this lag, operating capital is essential in operating any business. In the case of an egg products facility, payments must be made for eggs on delivery. The operating capital required for a two-machine egg products plant was estimated at $65,000, including total fixed and variable costs for a 3-week operation. At times the operating capital requirements might exceed this estimate as at the outset of an operation, since there will be little sales revenue during the first few weeks. If inventory stocks of raw materials or finished product build up, then additional capital will be required. A charge must be made for the use of this money even though a business is fortunate enough to have the needed capital, because it might be used for alternative investments.

FIXED AND VARIABLE COSTS

Fixed Overhead Costs

Fixed overhead costs include interest on investment and operating capital, depreciation, repair and maintenance,[6] and taxes and insurance. Annual fixed overhead costs were estimated at $55,375. An estimate for each overhead cost item is given in table 1. These costs will be incurred whether any product is processed or not. The magnitude of these expenses indicates the importance of volume on average overhead cost per pound of product processed.

Fixed Operating Costs

Fixed operating costs usually must be paid regardless of the quantity of product processed. They include salaries of managers, secretaries, and other personnel whose pay is not based directly on production rates. Salaried personnel assumed in this study are a manager, foreman, and secretary-bookkeeper with combined estimated wages of $29,500, including cost of Social Security, workmen's compensation insurance, health insurance, retirement, and other fringe benefits. These costs are included in table 2.

TABLE 2.—*Estimated number of employees and their wages for an egg products plant with 2 breaking machines* [1]

Employee classification	Employees	Wages
Production	*Number*	*Per hour*
Forklift truck operator	1	$2.75
Loaders	2	[2] 5.00
Graders	2	[2] 5.00
Breaking machine operators	2	[2] 5.50
Products employee	1	3.75
Packager	1	2.75
Materials handler and cleaner	1	2.50
Utility employee	1	2.75
Total	11	30.00
Administrative		*Per year*
Secretary-bookkeeper	1	6,500
Foreman	1	8,500
Manager	1	14,500
Total	3	29,500

[1] To determine whether the full potential of the work force is utilized will require a separate study involving work method analysis and evaluation.

[2] Total for 2 employees.

Other fixed operating costs include utilities used while the plant is not in operation. These costs were assumed to be $1,531, or 20 percent of the estimated annual cost of utilities when the plant is operating. The estimated annual costs for utilities for an egg products plant with two breaking machines are as follows:

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[6] Some repair and maintenance estimates are related to operating time and could be classed as variable costs. In this report all estimates for repair and maintenance are included as fixed overhead costs.

Heating of building	$ 663
Heating for processing	1,387
Water and sewage	1,133
Electricity	3,994
Telephone	480
Total	7,657

Heating, water, sewage, and electrical requirements were developed in earlier research (*9*). Heating costs are based on an assumed 17 cents per gallon of fuel oil, and the water, sewage, and electrical costs are based on the rates given in the appendix.

Other fixed operating costs include such items as memberships in trade associations and subscriptions to trade publications, which were estimated at $400 per year. The total fixed operating cost for salaries, utilities, and miscellaneous items was $31,431.

Variable Costs

Variable costs include wages paid production employees, utility expenses incurred while the plant is operating, cost of packaging materials, cleaning agents, office supplies, overtime, inspection, brokerage fees, and commission paid on sales. Some of these costs may be constant per unit of output, whereas others may vary with output, at least over specified ranges of output. For example, costs of packaging materials may be constant per unit of output unless the firm is able to get volume discounts on its purchases of packaging materials. Sometimes there are opportunities for increasing the productivity of labor and thereby decreasing the labor cost per unit of output. Utility companies frequently use a decreasing rate schedule, meaning that utility costs per unit decrease with increases in units purchased.

Labor Requirements

Production personnel employed to operate the model plant assumed in this study include a forklift truck operator, two loaders and two graders in the transfer room, two breaking machine operators and an egg products employee in the breaking room, a packager in the drawoff room, someone to assist in unloading and loading trucks and in plant cleanup, and a general utility employee, totaling 11 personnel. In addition, administrative personnel consisting of a secretary-bookkeeper, foreman, and plant manager are needed. In this report no consideration has been given to the labor needed and the other costs associated with the procurement of breaking stock and sale of finished products.

The forklift operator would move pallets of shell eggs, pallets of egg products, and empty pallets. The two loaders in the transfer room would transfer eggs from filler flats to the washing and grading machines and the two graders would remove undesirable eggs. The two breaking machine operators would run the breaking machines and remove certain types of eggs. The egg products employee would control the flow of egg products, add ingredients when needed, and control the pasteurizer as necessary.

The packager would prepare packaging material, then package and palletize the product and move it into the blast freezer. The materials handler and cleaner would assist in unloading, loading, and cleaning, and the utility employee would operate the heating and refrigeration equipment and perform service functions as needed.

Estimates of wages are given in table 2 for both the production and administrative employees. The estimate for the former, including fringe benefits, would amount to $30 per hour of operating time based on a 40-hour work week. Administrative costs would amount to $29,500 annually, or $14.75 per hour of operation, based on a 2,000-hour work year. These costs would vary from area to area and for overtime. They would also be affected by the number of hours of operation actually experienced by the firm.

Other Variable Costs

The estimated annual costs for utilities amounted to $7,657, of which $1,531 was included in the fixed operating expenses, leaving $6,126 as the allocation to annual variable costs of utilities. Based on 2,000 hours of operating time per year, the annual variable cost of utilities would amount to $3.06 per hour.

Packaging-material costs were assumed to be 45 cents per 30-pound container, the principal package form used for egg products. If plastic bags, portable tanks, or tank trucks are used, the packaging cost could average below the estimate assumed in this report.

It is not unusual for brokerage charges to amount to one-fourth of a cent per pound of egg product. Broker services are used in marketing a product not produced for a specific customer and would not normally be used for the entire output of the plant. In this study it was assumed that brokerage charges would average 0.1 cent based on total production.

Miscellaneous variable costs such as cleaning agents, uniforms, and office supplies were estimated at $3,200 per year.

COST ANALYSIS OF EGG-BREAKING OPERATION

The investment requirements and fixed and variable cost estimates developed previously as well as input-output relationships are analyzed here to determine costs and returns at various output levels.

Normal Operating Level

Normal operating level is assumed to be 2,000 hours per year with an annual production of 5,530,000 pounds obtained from 140,000 cases of eggs. Estimated annual costs totaled $244,612 for the normal operating level (table 3). Estimated average total processing costs amounted to 4.4 cents per pound; 2.8 cents of this average, or 64 percent, was attributed to variable costs and the remaining 1.6 cents, or 36 percent, to fixed overhead and fixed operating costs. These costs do not include shell egg assembly and product distribution costs, other than a small allowance for brokerage charges. No allowance has been made in table 3 for storage costs for frozen egg products.

TABLE 3.—*Estimated processing costs for an egg products plant with 2 breaking machines* [1]

Item	Processing costs	
	Annual	Average per product pound
	Dollars	*Cents*
Fixed overhead:		
Interest	18,137	0.328
Depreciation	19,886	.360
Repair and maintenance	9,334	.169
Taxes and insurance	8,018	.144
Total	55,375	1.001
Fixed operating:		
Salaries (administrative)	29,500	.533
Utilities [2]	1,531	.028
Miscellaneous	400	.007
Total	31,431	.568
Variable:		
Wages (production)	60,000	1.085
Utilities [2]	6,126	.111
Packaging materials	82,950	1.500
Brokerage fees	5,530	.100
Miscellaneous	3,200	.058
Total	157,806	2.854
Grand total	244,612	4.423

[1] Based on 2,000-hour operation annually and 5,530,000-pound production.

[2] Utilities costs were allocated 20 percent to fixed operating and 80 percent to variable costs.

Packaging materials were the largest single cost item, amounting to 34 percent of the total annual cost. Several large users of egg products have shifted from frozen eggs in 30-pound cans to fresh nonfrozen eggs in portable tanks or tank trucks in order to achieve savings in packaging and distribution costs as well as to avoid freezing and storage costs. The use of nonfrozen liquid eggs in small disposable containers is also expanding in some sections of the country. Wages of production employees were the second highest cost item, amounting to 38 percent of variable costs and more than 24 percent of the total annual cost. Salaries were the third largest cost item, amounting to 12 percent of the total annual cost. These three largest cost items—packaging materials, wages, and salaries—accounted for 70 percent of the total annual cost.

The wage cost estimates (table 3) were based on the labor requirements in table 2 and an assumed production of 2,765 pounds of product per hour of operation. If the assumed output is reduced 10 percent to 2,488.5 pounds per hour and all other costs except packaging are unchanged, the average total cost per pound would amount to 4.7 cents compared with the 4.4 cents (table 3).

Average Fixed Cost-Output Relationships

Estimated annual fixed overhead and fixed operating costs amounted to $86,806. Since these costs are essentially incurred without regard to the volume of output within the capacity range of the plant, the average fixed cost per unit of output or per unit of operating time decreases as output increases.

For example, the estimated fixed cost per hour of operation declined from $173.61 when operating for only 500 hours per year to $43.40 when operating for 2,000 hours per year (table 4). On a per case basis, estimated fixed cost declined from $1.55 with an annual volume of 56,000 cases to $0.56 with an annual volume of 154,000 cases. The fixed cost per case in this table (col. 5) corresponds to the number of cases (col. 2) and the estimated total annual fixed cost of $86,806. On a per pound of product basis, estimated fixed cost declined from 3.92 cents with an annual volume of 2,212,000 pounds to 1.43 cents with an annual volume of 6,083,000 pounds. Estimated fixed cost per pound of product (col. 6) corresponds to the annual volume data (col. 3) and the estimated total annual fixed cost of $86,806.

An operator of an egg products processing facility would need to estimate his expected annual fixed cost and then determine his expected fixed cost-output relationships as shown in table 4.

TABLE 4.—*Estimated average fixed cost-output relationships annually for an egg products plant with 2 breaking machines*[1]

Operating time (hours)	Cases [1]	Product [2]	Fixed cost [3] per— Hour of operation	Case	Pound of product
	Number	*Pounds*	*Dollars*	*Dollars*	*Cents*
100	7,000	276,500	868.06	12.40	31.39
200	14,000	553,000	434.03	6.20	15.70
300	21,000	829,500	289.35	4.13	10.46
400	28,000	1,106,000	217.01	3.10	7.85
500	35,000	1,382,500	173.61	2.48	6.28
600	42,000	1,659,000	144.68	2.07	5.23
700	49,000	1,935,500	124.01	1.77	4.48
800	56,000	2,212,000	108.51	1.55	3.92
900	63,000	2,488,500	96.45	1.38	3.49
1,000	70,000	2,765,000	86.81	1.24	3.14
1,100	77,000	3,041,500	78.91	1.13	2.85
1,200	84,000	3,318,000	72.34	1.03	2.62
1,300	91,000	3,594,500	66.77	.95	2.41
1,400	98,000	3,871,000	62.00	.89	2.24
1,500	105,000	4,147,500	57.87	.83	2.09
1,600	112,000	4,424,000	54.25	.78	1.96
1,700	119,000	4,700,500	51.06	.73	1.85
1,800	126,000	4,977,000	48.22	.69	1.74
1,900	133,000	5,253,500	45.69	.65	1.65
2,000	140,000	5,530,000	43.40	.62	1.57
2,100	147,000	5,806,500	41.34	.59	1.50
2,200	154,000	6,083,000	39.46	.56	1.43
2,300	161,000	6,359,500	37.74	.54	1.36
2,400	168,000	6,636,000	36.17	.52	1.31
2,500	175,000	6,912,500	34.72	.50	1.25

[1] Based on 70 cases per hour.

[2] Based on yield of 39.5 pounds per case.

[3] Based on estimated annual fixed cost of $86,806.

Costs and Returns

The estimated average fixed and variable processing costs for various operating times are given in figure 9. These cost relationships were estimated on the basis of an assumed output of 2,765 pounds of product per hour of operation. Average variable costs were estimated at 2.8 cents per pound (table 3) for a 2,000-hour annual operation. Variable costs are assumed to increase 0.868 cent per pound of product for all output above 2,000 hours, 0.543 cent for overtime labor, and 0.325 cent for inspection fees paid by the processor.

The assumed annual production for the plant was 5,530,000 pounds. The expected revenue was estimated by using the assumed production and the average wholesale price in the New York City-Philadelphia area for light-colored frozen whole eggs during 1963–72 (table 8, appendix). The average annual wholesale price ranged from 22.2 cents per pound in 1972 to 30.5 cents in 1969. The 4-year average wholesale price was 25.9 cents and resulted in a gross revenue estimate of $1,432,270 per year.

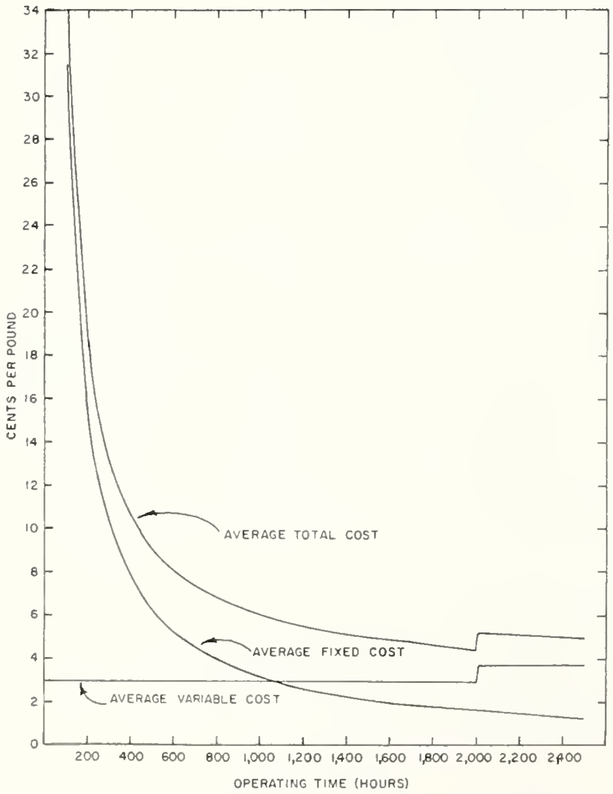

FIGURE 9.—Estimated average fixed and variable egg products processing costs as related to operating time.

Marketing of egg products can be accomplished by various methods and in various forms. The 25.9-cent estimate is based on marketing frozen whole eggs through brokers. However, sales may be made directly to large concerns, such as bakeries, restaurants, institutions, hotels, and other outlets. The production may be marketed fresh and in forms other than whole eggs, such as whites, yolks, sugared yolk, salted yolk, fortified whole egg (yolk added), and various blends as specified by special use buyers. These forms sell at higher prices and require additional production costs.

The breaking stock for an egg products operation may consist of unclassified or nest run eggs, undergrades, and checks.[7] Undergrades and checks are two of the essential sources of breaking stock. Estimated average prices for breaking stock delivered to processing plants at selected locations are given in table 5 for 1969–72. For purposes of analysis the breaking stock was assumed to consist of one-half unclassified, one-fourth undergrade, and one-fourth check eggs. For the southeastern area this procedure resulted in an average cost of breaking stock of $7.22 per case ($7.83 + $7.83 + $7 + $6.22 ÷ 4) for 1969–72. Based on an assumed yield of 39.5 pounds per case (*2*), the cost of breaking stock would be equivalent to 18.3 cents per pound (table 5), or a gross margin of 7.6 cents per pound (25.9 − 18.3).

The cost of storage, loading, shipping, allowance for bad debts, and interest on accounts receivable must be taken into account when estimating potential costs and returns. In this study these costs were assumed to total 2.5 cents per pound of product produced. When these costs are included, the adjusted gross margin faced by the management of the processing facility was estimated at 5.1 cents per pound of product (7.6 − 2.5 cents).

Price Spreads

The price spread between the New York City-Philadelphia area wholesale price for frozen

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[7] Use of leakers and inedibles or loss eggs is prohibited by law.

TABLE 5.—*Estimated average prices paid for breaking stock eggs delivered to plants in 3 production areas, 1969–72*

Year	Southeastern area[1]			Iowa and Nebraska	Missouri and Kansas
	Unclassified[2]	Undergrades	Checks	unclassified[3]	unclassified[3]
	PRICE PER CASE WITH CASES EXCHANGED				
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1969	9.83	8.96	8.17	9.86	9.15
1970	8.50	7.53	6.58	8.66	8.38
1971	6.65	5.90	5.14	6.44	6.07
1972	6.33	5.59	4.97	6.17	5.72
Average	7.83	7.00	6.22	7.78	7.33
	PRICE PER POUND OF CONVERTED LIQUID WHOLE EGGS[4]				
	Cents	*Cents*	*Cents*	*Cents*	*Cents*
1969	24.88	22.68	20.68	24.96	23.16
1970	21.52	19.06	16.66	21.92	21.21
1971	16.84	14.94	13.01	16.30	15.37
1972	16.02	14.15	12.58	15.62	14.48
Average	19.82	17.72	15.74	19.70	18.56

[1] Includes Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee.

[2] Nest run; minimum average gross weight of 52 pounds.

[3] Minimum average gross weight of 53 pounds.

[4] Based on assumed yield of 39.5 pounds of liquid eggs per case of breaking stock.

Source: U.S. Dept. Agr. Consum. and Mktg. Serv. SB514, "Poultry Market Statistics," Mar. 1973.

whole eggs and the price for breaking stock on a yield basis was determined for three major production areas for 1969–72. For the southeastern area, price spreads were determined for three classes of breaking stock—unclassified, undergrades, and checks. As expected, price spreads were greatest for checks, followed by undergrades and then unclassified (table 6). The 1969–72 estimated average price spread was 10.1 cents per pound of product for checks delivered to southeastern plants, 8.1 cents for undergrades, and 6.1 cents for unclassified.

For the Iowa and Nebraska area, the estimated price spread for unclassified averaged 6.2 cents per pound for 1969-72 and ranged from 5.3 cents in 1970 to 7.2 cents in 1971. For the Missouri and Kansas area, the estimated price spread for unclassified eggs averaged 7.3 cents per pound for 1969–72 and ranged from 6 cents in 1970 to 8.1 cents in 1971.

These price spreads provide a measure of the potential gross margins available to reward resources used in egg-breaking operations, including processing, packaging, freezing, storing, shipping, and selling.

Market Trends

Frozen egg prices advanced rapidly during the first 6 months of 1973, as did prices of most food and nonfood products. The New York-Philadelphia area wholesale price for frozen eggs rose from 32 cents per pound in early January to 45 cents by mid-July. With low stocks and a strong demand for frozen eggs, breaking stock prices also climbed during this period. Unclassified breaking stock prices in the Southeast and Midwest rose from approximately 39 cents per dozen in early January to 46 cents in mid-July. Estimated processing margins widened from 2.4 to 10.1 cents per pound during this period. Processing margins for undergrade eggs were greater than those calculated for unclassified breaking stock, climbing from 6.6 cents in early January 1973 to 13.5 cents per pound in mid-July.

TABLE 6.—*Estimated average price spreads per pound of product between New York City-Philadelphia area wholesale price for frozen eggs and selected breaking stock prices converted to liquid egg basis, 1969–72* [1]

Year	Southeastern area [2]			Iowa and Nebraska unclassified [4]	Missouri and Kansas unclassified [4]
	Unclassified [3]	Undergrades	Checks		
	Cents	*Cents*	*Cents*	*Cents*	*Cents*
1969	5.6	7.8	9.8	5.5	7.3
1970	5.7	8.1	10.5	5.3	6.0
1971	6.7	8.6	10.5	7.2	8.1
1972	6.2	8.0	9.6	6.6	7.7
Average	6.1	8.1	10.1	6.2	7.3

[1] Based on assumed yield of 39.5 pounds of liquid eggs per case of breaking stock.

[2] Includes Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee.

[3] Nest run; minimum average gross weight of 52 pounds.

[4] Minimum average gross weight of 53 pounds.

Break-Even Point Volume

The break-even point volume for the model plant used in this study was estimated as follows:

$$Y = \frac{F + FO}{P - (BP + VC + T)}$$

Where:

Y = Break-even point volume

F = Annual fixed overhead cost

FO = Annual fixed operating cost

P = Wholesale price per pound delivered to New York City-Philadelphia area

BP = Breaking stock price per pound delivered to processing plant

VC = Average variable cost per unit of output

T = Transportation, storage, and selling costs

$$Y = \frac{55{,}375 + 31{,}431}{0.2590 - (0.1830 + 0.0285 + 0.0250)}$$

$$= \frac{86{,}806}{0.2590 - 0.2365}$$

$$= \frac{86{,}806}{0.0225}$$

$$= 3{,}858{,}000 \text{ pounds}$$

Based on data developed in this study, potential net returns of $37,000–$38,000 per year could be obtained from a two-machine egg-breaking operation. Processing margins and resulting net returns vary sharply from year to year and this variability could adversely affect an operation by placing financial burdens on a firm during periods of relatively low processing margins. The amount of operating capital needed in such periods could be considerably greater than the requirements assumed in this study.

In the previous example, if frozen egg prices average one-half cent per pound lower than assumed or if processing and marketing costs are one-half cent per pound higher, the break-even volume would increase to 4,960,000 pounds and potential annual net returns would drop to roughly $10,000. The results in this example indicate the sensitivity of the size of processing and marketing margins on potential net returns in egg-breaking operations. In the final analysis, each prospective investor should use the expected cost and return data appropriate to his individual situation.

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APPENDIX

The assumed monthly rate structures used in calculating water, sewage, and electricity costs are as follows:

WATER AND SEWAGE

Amount (ft^3)	*Rate per 100 ft^3*
0–3,200	$0.7125
3,201–6,500	.6675
6,501–13,000	.6075
13,001–26,500	.5475
26,501–46,500	.4650
Over 46,500	.4275

ELECTRICITY

Amount (kWh)	*Rate per kilowatt-hour*
0–300	$0.028
301–1,000	.023
1,001–3,000	.019
3,001–7,200	.015
7,201–16,400	.009
Over 16,400	.005

TABLE 7.—*Shell and processed eggs: Per capita consumption, United States, 1951–71*

Year	Per capital consumption of—			Processed egg consumption as proportion of total
	Shell eggs	Processed eggs [1]	All eggs	
	Number	*Number*	*Number*	*Percent*
1951	365	27	392	6.9
1952	362	28	390	7.2
1953	354	25	379	6.6
1954	351	25	376	6.6
1955	346	25	371	6.7
1956	345	24	369	6.5
1957	335	27	362	7.5
1958	328	26	354	7.3
1959	319	33	352	9.4
1960	306	28	334	8.4
1961	298	30	328	9.1
1962	296	30	326	9.2
1963	290	27	317	8.5
1964	288	30	318	9.4
1965	286	28	314	8.9
1966	284	30	314	9.6
1967	289	35	324	10.8
1968	289	32	321	10.0
1969	287	31	318	9.7
1970	286	33	319	10.3
1971	285	37	322	11.5

[1] Computed on shell egg equivalent basis.

Source: U.S. Dept. Agr. Agr. Handb. 348, "Handbook of Agricultural Charts, 1967," data published currently in U.S. Dept. Agr. Econ. Res. Serv., "Poultry and Egg Situation Reports."

TABLE 8.—*Average monthly wholesale prices per pound of light-colored frozen whole eggs, New York City-Philadelphia area, 1963–72*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
1963	25.6	29.4	28.7	26.4	25.6	25.2	25.7	26.2	27.3	27.4	26.9	27.2	26.8
1964	28.6	27.4	26.5	25.2	24.9	24.7	25.4	25.7	26.2	26.2	25.6	24.2	26.0
1965	22.8	22.8	22.7	23.3	24.2	25.8	26.5	26.4	26.3	27.9	29.1	30.1	25.7
1966	28.6	31.3	34.8	33.2	29.3	29.1	29.6	31.7	32.8	32.3	34.1	34.9	31.8
1967	30.2	27.0	25.9	24.3	24.5	24.6	24.3	24.3	23.8	22.3	22.5	22.4	24.7
1968	21.9	21.4	22.2	22.3	22.2	23.5	23.8	23.5	24.7	26.7	27.3	27.1	23.9
1969	27.3	27.4	27.5	27.3	26.4	26.0	27.0	28.5	31.2	35.2	40.7	41.7	30.5
1970	39.0	35.2	28.6	25.0	24.5	24.5	25.5	25.1	25.1	24.2	24.7	24.7	27.2
1971	24.0	23.5	24.1	23.6	23.8	23.8	23.6	23.2	23.0	23.1	23.0	23.0	23.5
1972	22.5	21.7	21.6	21.2	21.5	21.4	21.3	21.1	21.5	21.7	22.8	27.4	22.2
Average	27.1	26.7	26.3	25.2	24.7	24.8	25.3	25.6	26.2	26.7	27.7	28.3	26.3

Source: U.S. Dept. Agr. Consum. and Mktg. Serv., SB514, "Poultry Market Statistics," Mar. 1972.

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